TABLE 2. THE EFFECT OF PEAR PSYLLA FEEDING ON WINTER NELIS AND BARTLETT TREES ON DIFFERENT ROOTSTOCKS IN THE FIELD, DAVIS, 1962

Rootstock	Number of trees	Trees with red foliage on Oct. 25*	Number that collapsed
Pyrus serotina (Oriental)	17	11	2**
P. ussuriensis (Oriental)	9	6	0
P. calleryana (Oriental)	5	5	0
P. communis			
Variolosa rooted cuttings	8	0	0
Old Home rooted cuttings	7	0	0
Bartlett seedlings	12	0	0

* An equal number of trees designated as controls were also examined but none developed red foliage.
** Both trees that collapsed were diagnosed as positive for phloem necrosis. A single control (P. serotina) was also sampled for phloem necrosis and diagnosed negative. For comparison, one control and one infested tree on Old Home roots were sampled and both found to have normal phloem.

branches having separate graft unions, about half of the 133 test trees received psylla on only one scion branch while the remainder received psylla on all scions. The results thus far indicate that adverse effects on susceptible trees occur at about the same rate and extent regardless of the number of grafts upon which psylla are feeding.

These studies indicate that the pear psylla introduced some factor into the young pear trees on *Pyrus serotina* rootstocks that adversely affected the entire tree. The symptoms produced included retarded growth, reddening of the foliage, phloem necrosis and brown line at the graft union, wilting and collapse. A toxin could account for the effects in trees experimentally infested with pear psylla although this does not exclude the possibility of a virus being involved. However, one control tree developed decline symptoms and one other tree (not treated as a control, but apparently free of psylla feeding) collapsed. In these two cases, the disease must have been initiated by the feeding of only one or a few adults. The similarity of pear decline symptoms in commercial orchard trees and those induced by pear psylla feeding on young trees in these field plots substantiates greenhouse evidence by workers in Washington and California in showing an intimate relationships between pear psylla and decline.

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P. H. WESTIGARD · H. F. MADSEN

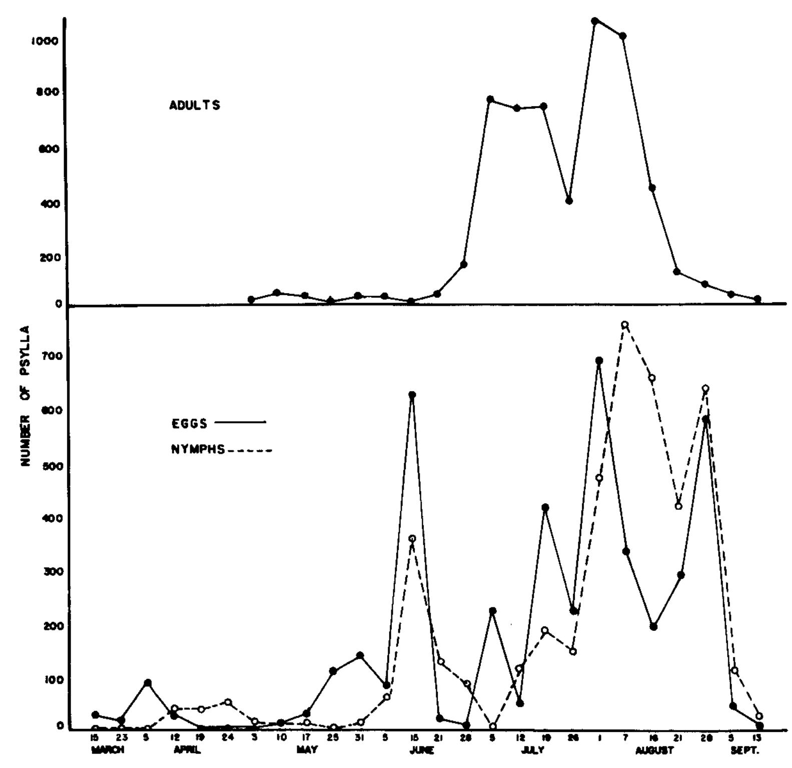
PEAR PSYLLA

in Abandoned Orchards

Abandoned orchards studied during the 1962 season showed substantial variation in their ability to support heavy populations of the pear psylla. There were indications that trees abandoned for several years may have arrived at a point where biological control factors will control the densities of this pest. The removal of single trees or of entire orchards that had been in this neglected state for several years is, therefore, of questionable value. However, in those orchards left unsprayed for only one or two years, psylla populations did reach high densities. Under these high summer population levels, several psylla adults were captured on traps placed considerable distances from the orchard. This greatly increases the danger from abandoned orchards in the adequate control of this pest in commercial plantings.

El Dorado County, in the Sierra foothills, has been one of the areas in California most ravaged by pear decline. As the orchards became commercially unprofitable, they were abandoned in many cases. While it is likely that most of the trees in these orchards will eventually die, they represent potential reservoir areas, while alive, for the buildup of the pear psylla—and a threat to the remaining commercial plantings. To evaluate this problem the University of California, in cooperation with the California State Department of Agriculture, re-

Graph 1—Pear psylla populations in abandoned orchard at Placerville, 1962.



moved large numbers of trees from abandoned orchards in this area to determine the effects of this removal on the general psylla population. Biological studies were also set up along with this program.

The sites selected for these studies were located in El Dorado and Sacramento counties in Northern California. The orchards were in conditions of total or semi-abandonment.

El Dorado orchard

One test orchard near Camino, about eight miles east of Placerville, had been planted on Japanese rootstock which is highly susceptible to pear decline disease. The orchard had become unprofitable in 1960 and was not pruned, irrigated or sprayed during 1961 and 1962. In the spring of 1962 the trees displayed an excellent bloom and some shoot growth. However, after this period no new shoot growth was evident and by the end of the summer most of the trees in the 7- to 8-acre block had died.

Psylla populations were sampled in the late winter and early spring by taking 50 fruit buds at random, but counts thereafter were made from collections of 100 pear leaves. Eggs and nymphs were counted in the laboratory. Samples were collected weekly from March through October. Adult counts were made in the field by tapping shoot terminals onto a beating sheet. The population trends from this orchard are presented in Graph 1. On the first sampling date, March 15, eggs laid by the overwintering females were already present. The first nymph appeared in the sample taken approximately one month later, on April 12. On this date all nymphs were in early instars and it was not until the 24th of April that the first "hardshell" was found. It can be inferred that this first generation required about two months to complete its development. During this period the population density remained at a relatively low level but at the beginning of June a sharp increase was noted.

Nymph population

A significant depression of the nymphal population was evident in early July, associated with the extensive crystallization of the honeydew droplets in which the early instars reside. A resumption in buildup of the psylla nymphs continued through August and September, followed by a general decrease in density of all stages. This final reduction can be attributed to the exceedingly poor condition of the host plants. There were four or five generations in the above orchard, as indicated on Graph 1.

Even though this particular orchard had been freed of the selective pressure resulting from pesticide application, very few predators or parasites were found. Toward the end of the summer months several green lacewing (*Chrysopa*) nymphs and adults were collected but there was a notable absence of the reportedly effective anthocorid predators. The large amounts of honeydew secreted by the psylla nymphs did attract several species of bees and wasps which were noted on several occasions to remove the honeydew surrounding the early instars. This may have had a limited effect by exposing these delicate forms to desiccating influences. As mentioned above, a definite suppression of the nymphal population was associated with honeydew crystallization. This had only a temporary effect, however, and could not be considered to be a regulatory agent.

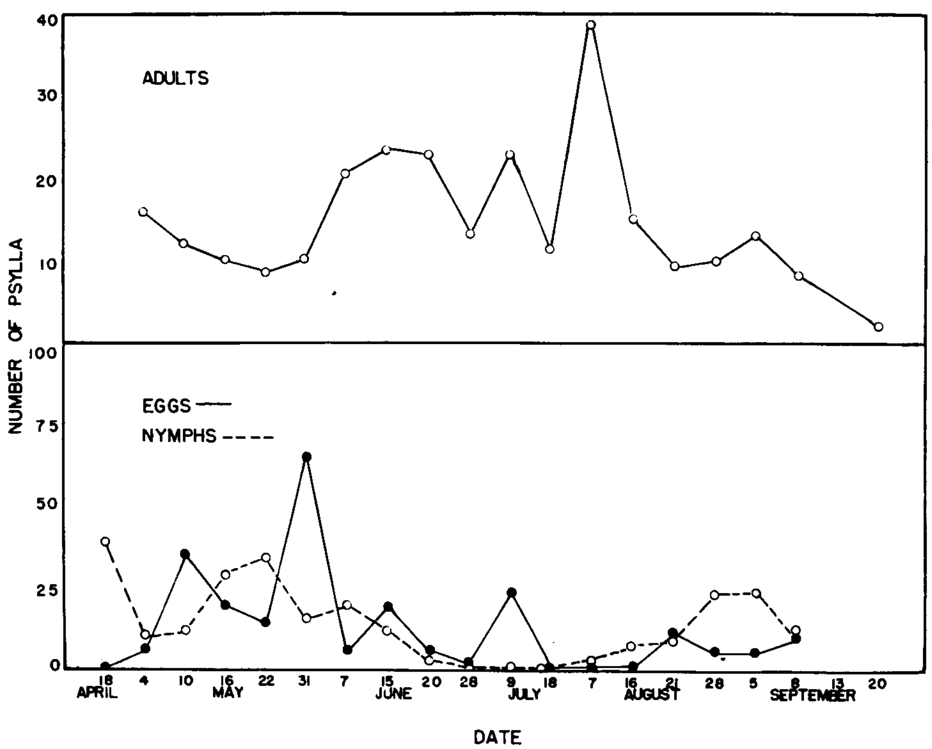
Sacramento orchard

The Sacramento County study area was located about three miles west of Walnut Grove along the Sacramento River. The orchard had been neglected for several years, and only scattered trees remained. The condition of the trees was good, however, with new growth present through most of the summer. No pesticide or fungicide applications had been made in 1962—nor for several years preceding.

The sampling procedures were similar to those reported from the abandoned orchard in El Dorado County. The first sample was taken on April 15 and the last on September 13. As seen in Graph 2, the number of psylla remained quite low through the entire season, much in contrast to the fluctuations which occurred in the Camino orchard. This discrepancy in density extremes was most obviously explained by the climatic differences between the two areas. High summer temperatures, common in the Sacramento River area, have been reported to retard oviposition by the females and also to kill the early instars of the pear psylla.

The presence of several species of predaceous insects was noted through the summer in the samples taken from the Sacramento orchard. Larvae and adults of green lacewings and adult anthrocorids

Graph 2—Pear psylla populations in abandoned orchard at Sacramento, 1962.



were the most common predators; but neither occurred in large numbers, and it could not be determined if these insects accounted for the low number of psylla. It is becoming increasingly evident that psylla populations very seldom reach high densities in orchards which have been abandoned for three to four years. This phenomenon has also been observed in several other areas. Psylla population trends from the Sacramento orchard are presented in Graph 2.

Movements of psylla

The pear psylla's dispersal powers are evident in the rapid spread through California pear-growing areas. It is thought, however, that the principal movements generally take place only in late fall and early spring, involving females and males of the overwintering generation. Reports from the Northwest indicate that psylla of the summer generations move very little, even from tree to tree in the same orchard. If this were true under California conditions, the importance of the abandoned orchards as psylla reservoirs would be minimized—except for distribution into commercial orchards in the fall.

To determine whether the summer movements of the psylla differed under California conditions, sticky traps were placed at various distances from two orchards in El Dorado County. In the Camino orchard, the traps were not installed until mid-August but the results showed a high degree of mobility under the population densities existing at that time.

In this orchard, twenty-two 6 × 8-inch boards were smeared with the sticky substance "Deadline," and hung from trees or shrubs surrounding the orchard. The distances of each trap from the nearest pear tree and the number of psylla caught appear in the table. Females were trapped in a 2:1 ratio to males. This was the same proportion existing at this time within the orchard.

STICKY TRAP RECORD SHOWING NUMBER OF PSYLLA CAUGHT AT DISTANCES FROM CAMINO ORCHARD

Distance from trap to nearest pear tree in feet	Number of traps	Number of psylla Date					
		August			September		
		16	21	28	5	13	20
10–20	6	21	8	9	4	2	0
20–50	3	11	2	1	0	0	0
50–80	3	18	1	7	2	0	0
80–110	2	9	3	3	0	0	0
110–150	2	2	1	0	0	0	0
150–250	1	0	0	0	0	0	0
250–300	1	–	1	0	0	0	0
300–350	2	–	–	1	0	0	0
350–450	0	–	–	–	–	–	–
450–550	1	–	0	0	0	0	0
550–650	1	–	0	0	0	0	0

The second orchard was located near Kelsey, in El Dorado County—an area with few commercial plantings of pears remaining. It had been cared for until mid-July when it was abandoned. Traps were placed downwind on two sides of the orchard. Only one psylla was found on the traps, but the psylla population in the orchard never reached the high levels found in the Camino orchard.

In addition to the two areas already mentioned, evidence substantiating summer movements of the pear psylla was

EVIDENCE FOR VIRUS AS A CAUSE OF PEAR DECLINE

PRELIMINARY RESULTS of experiments in progress for two years indicate that a transmissible agent, believed to be a virus, caused pathological effects at the graft union of pear trees identical to those associated with pear decline. Symptoms were brown discoloration of the cambial surface of the bark (brown line) and formation of abnormal replacement phloem. This is the first direct evidence that a virus is a cause of pear decline. The manner in which the disease has spread along the Pacific Coast and throughout most of California strongly suggests that it is carried by an airborne insect.

Two transmission trials were performed. In the first, test plants were 42- to 43-year-old Bartlett trees on *Pyrus ussuriensis*, Maxim rootstock, in DiGiorgio Fruit Corporation's Dantoni orchard near Marysville. In the second trial, 2-year-old Bartlett trees on *P. serotina*, Rehd. seedling rootstock, were observed in a University nursery near Davis. All were apparently healthy at the beginning of the experiments and had normal phloem as indicated by microscopic examination of bark samples removed from the graft union.

In 1960, tissues from trees in various stages of pear decline were grafted to each of 54 orchard trees. One hundred and three of the nursery trees were inoculated in a similar manner in 1961. In each experiment an equal number of trees received no treatment or were grafted with tissue from healthy trees as controls. After inoculation, bark samples were removed from the graft union of each of the 314 trees on two occasions. These were prepared for macroscopic and microscopic determination of pathological phloem.

So far, relatively few of the test trees in either plot have apparent foliar symptoms of pear decline. However, the inoculated trees in both plots developed a higher incidence of phloem irregularities than did the controls. After two years, 69% of the inoculated trees in the orchard plot developed brown line or replacement phloem compared to 39% of the control trees. In the nursery, 15% of the inoculated trees had pathological phloem after one year compared to 3% of the controls. These graft union symptoms were identical to those of the inoculum source trees and typical of pear decline. Statistical analysis revealed that the differences were highly significant (1% level) in each experiment, indicating transmission to both mature orchard trees and young trees in the nursery.

A graft-transmissible agent, therefore, can apparently cause pathological effects in the phloem of pear trees, which are believed to be symptoms of pear decline. Since previous studies have failed to show that fungi or bacteria have primary roles in causing the disease, the transmissible agent is believed to be a virus. Further studies are in progress to determine if the transmissible agent can multiply in the host—a primary property of viruses—and whether it causes other symptoms of the disease.—*T. A. Shalla, Assistant Plant Pathologist, Agricultural Experiment Station, and Chairman of the Pear Decline Committee, University of California, Davis; Luigi Chiarappa, Plant Pathologist, DiGiorgio Fruit Corporation; and T. W. Carroll, Laboratory Technician, U.C., Department of Plant Pathology, Davis.*

obtained from several commercial orchards. It was observed that commercial orchards located in areas near abandoned orchards were more rapidly reinfested after pesticide treatment for psylla control than commercial orchards located in areas where abandoned orchards had been removed.

Reinvasion possibilities

It has been shown in these tests that abandoned orchards are capable of supporting large numbers of the pear psylla. It was also indicated that summer movements out of these neglected areas do occur. In view of these findings it could be assumed that commercial orchards located near these sources would be more subject to quick reinvasion following pesticide treatment than those located in areas free of abandoned trees. If this assumption were true, the removal of abandoned orchards would be of immediate importance in reducing the pest reportedly responsible for the pear decline disease.

To check this point, five orchards were studied in the Placerville area. Three were in close proximity to abandoned orchards, and two were in areas free of neglected trees. All five orchards were treated by the growers with Guthion for psylla control, and in all orchards but one, two foliar applications were made. All three of the orchards located near abandoned trees had persistent but low psylla numbers throughout the season, which are believed to have originated from immigrating individuals. This was in contrast to the total absence of psylla recorded from the two orchards in the area free of abandoned trees.

Nymphal population in reinvaded orchards was low, probably because of the toxic residue of Guthion on the foliage. Thus, the effect of immigration from abandoned orchards may be minimized by application of an effective, long-residual pesticide. However, judging by the number of compounds to which the pear psylla has become resistant in the states of Oregon and Washington, there is little chance of maintaining the current effectiveness of materials such as Guthion.

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PEAR DECLINE RESEARCH

H. F. MADSEN · P. H. WESTIGARD

CONTROL OF PEAR PSYLLA

with Oils and Oil-Pyrethrins

Oil sprays show promise for pear psylla control, but the addition of pyrethrins offers little advantage.

PEAR PSYLLA can be readily controlled in California at the present time with several of the organic phosphate insecticides, as well as dieldrin and Dilan. Some of the organic phosphates (malathion and Diazinon, principally) have failed to give adequate control, however, and it is probable that resistance will become an important factor in the near future, especially if an intensified program of control is continued. The extensive resistance problem reported in Washington is perhaps a preview of what may soon occur in California.

Since an intense screening program on new insecticides is underway in the Pacific Northwest, it was decided to limit the 1962 studies in California to an investigation of petroleum oils and pyrethrins. Three oils with a wide range of viscosity were applied, alone and in combination with pyrethrins. The oils used were: Pennsalt Superior oil (viscosity 70–75, U.R. 96.0), Moyer oil 94 (viscosity 507, U.R. 92.0), and Moyer oil 97 (viscosity 1035, U.R. 91.2).

A plot was established in an isolated section of an abandoned orchard at Danville. For each material, plots consisted of single trees with five replications in a restricted, randomized design. The sprays were applied with a conventional power sprayer and hand guns. Approximately five gallons per tree were used at each application.

The plots were evaluated by collecting five basal leaves and five terminal leaves from each replicate and examining them for pear psylla nymphs and eggs—with the aid of a binocular microscope. The

SUMMARY OF 1962 OIL AND PYRETHRIN PLOTS FOR CONTROL OF PEAR PSYLLA

Materials	Dosage per 100 gallons*	Nymphs per 50 leaves										
		May 31	June 5	June 18	July 2	July 18	July 26	Aug. 2	Aug. 8	Aug. 21	Sept. 6	Sept. 18
Pennsalt Superior oil	1 gallon	395	9	12	4	42	35	57	25	14	3	20
Moyer oil 94	1 gallon	253	61	32	3	8	16	1	6	3	4	21
Moyer oil 97	1 gallon	228	41	43	1	25	11	15	6	4	1	6
Pennsolt Superior oil + pyrethrins	1 gallon + 2 pints 2%	252	16	13	1	49	24	16	45	8	3	10
Moyer oil 94 + pyrethrins	1 gallon + 2 pints 2%	214	9	15	6	20	18	5	10	5	1	5
Moyer oil 97 + pyrethrins	1 gallon + 2 pints 2%	386	28	10	0	12	30	10	18	0	4	7
Pyrethrins	2 pints 2%	215	50	158	19	35	156	9	149	91	–	–
Check	no treatment	266	116	129	8	90	70	80	362	141	120	33

*Materials applied Moy 31, July 26.